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ARCHITECTURAL MODEL FOR THE SPECIAL UNIT MACHINERY MRICC 8 × 1250 - 6U CNC

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Abstract: *This article proposes an architectural model that can be applied in the field of machine-tool and it is based on various expert systems having an advanced process interface, dedicated to the main domains of sustaining the operation in machine-tool parameters. A complex field for the usability of these models is The Super-control of Automatic Production System (SC-AMS). The programmed models represent a promising research field because of their usability, especially in productivity terms. The architectural model is being conceived in order to be applied in the SC-AMS field, basing on the special unit machinery MRICC 8 × 1250 – 6U CNC.*

Key words: *expert system, architectural model, special machinery, computerized systems.*

1. INTRODUCTION

Nowadays, the architectural model represents an efficient technique used to combine the computerized models. This model contains a structural scheme consisting of a predefined subsystem set, each set having its role or/and rules well defined, the general principles of its organization and relations with other subsystems.

In order to obtain a better degree of usage and understanding for the architectural model, the present article has as starting point the special unit machinery MRICC 8 × 1250 – 6U CNC.

The machinery MRICC 8 × 1250 – 6U CNC having annular rotating table and central column is a specialized machinery, intended for machining the lug boss used for mounting the thermal screen and the holes used for mounting the exhaust flange, afferent to the “K” motor collector, used for LOGAN motorcars. Although it is a special machine-tool dedicated to a restricted set of operations it can be considered representative for the cutting machines and needs the implementation of some expert systems because of the following aspects:

- the implementation of machine and specific operations within the factory in a relatively short time, do not allow a good operator’s preparation;
- the large number of parts needed for the new operations must be controlled and assured during the production process;
- it requires the necessity of a specialized assistance for maintenance and control.

2. ARCHITECTURAL MODEL/EXPERT SYSTEM (ES)

The architectural model ISO-OSI (Open System Interconnection) divides the network architecture in subsystems, realized one on top of the other, adding functionality to services provide by the inferior level. The model is not specifying the way that the subsystems are built but insists upon services provided by each one and specifies the communication way between subsystems by means of interfaces. Each producer can build the subsystems as they please, but each subsystem must provide a certain set of services. The designing of the architecture on subsystems can determine the extending or the improvement of the system.

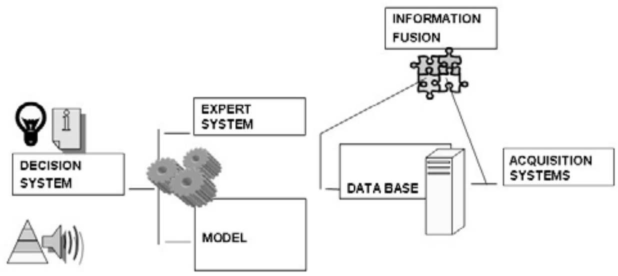

Fig. 1. Flow Chart.

Each subsystem of the architectural model is an expert system (ES) having an advanced process interface (Fig. 1), acquired by factors collaboration, collaboration resulting from the relations established between rules at one time with increasing the time of incrementation.

“The expert systems are programs conceived to rationalize in order to resolve problems that otherwise requires a considerable human expertise” (Edward Feigenbaum, Stanford University).

The structure of an expert system must contain three main modules that form the essential system:

The knowledge base: it consists of the specialized knowledge introduced by the human expert. The knowledge stocked in here is principally the description of the objects and the relations between them. The knowledge base is part of the cognitive system, the knowledge being memorised within a special organized space. The way of stocking must assures searching of the specified knowledge pieces directly by means of identifying symbols or indirectly by means of associated or inference properties that start from other knowledge pieces;

The inference mechanism (or engine) represents the novelty of the expert systems. It takes over the acts used for building the reasoning from the knowledge base. The inference mechanism pursues major objective such as: selecting the control strategy by taking into account the present problem, issuing the plan for solving the problem by taking into account the necessities, switching from one control strategy to another, carrying out the actions foreseen in the solving plan. Although the inference mechanism consists of an assembly of procedures in the proper meaning, the way of utilizing the knowledge is not provided by the program and depends of the knowledge that it has on its disposition.

The base of facts represents an auxiliary memory that contains all user's data (the initial facts that describe the statement of the solving problem) and the intermediate results issued during reasoning.

A lot of definitions of the expert systems (ES) can be offered and also a lot of classifications can be made starting from these. One thing is for sure, that the expert systems incorporate a knowledge base and an inference engine and that ES use inference procedures for solving problems. Many efficient searching strategies have been developed, such as the analysis, the tools/scopes used for the general solving of the problems and planning, the alpha-beta game strategies, the A* algorithm used for heuristic search. The ES have a high degree of generality.

In order to clear define the idea of ES one can enumerate the following characteristics:

- from the conceptual viewpoint, the ES SE regard the retrace of the human reasoning basing on the expert's expertise;
- ES dispose of knwledge and capacity for developing human intellectual activities;
- are organized for the knowledge acquisition and exploitation in a particular field named the problem field;
- dispose of knowledge invoking methods and the expertise expression behaving like an intelligent assistant;
- on the informatic level, ES is basing on the principle of separating the knowledge by the program that treats it;
- are capable of memorising the knowledge, to establish the connections between knowledge and to draw conclusions, to propose solutions and recommendations, to determine causes of some phenomena;

The literature shows other models too, but none of them except for the architectural model based on graphic representations proved no good applicability as regarding control and dispatch.

This paper presents an architectural model based on the design of the model subsystems that propose a strategy for an efficient solving of the SC-AMS system problems, such as decision and dispatch.

For the architectural model, dedicated to the special machinery MRICC 8 × 1250 – 6U CNC, the following expert systems have been chosen:

- ES - MONITORING
- ES – DIAGNOSIS
- SE - PREDICTIVE MAINTENANCE
- SE - DECISION, COORDINATION

The established order allows a logical interpretation of the events occurred on the machine-tool. Thus the information provided by monitoring sensors is being processed, assigned with a diagnostic that by taking into account other previous events will be classified in a problem range, which by means of beneficiary's options and other previously solved problems allow issuing of new solutions.

In this case for implementing the system, the machinery will be endowed with a set of sensors that will provide electrical signals to all elements. As a function of the control degree there can be a large number of sensors having high accuracy in order to assure static and dynamic measurements, manual, semiautomatic or automatic with command regime. Tools play a very important role in operations that use it as well as in the effect upon production, quality and characteristics being indispensable to the implemented model.

2.1. SE-monitoring

In this subsystems appear the first interpretations regarding information provided by sensors mounted on machinery, the electrical signals are converted in a program code, compared with intervals stocked within the DATA BASE OF SENSOR'S CHARACTERISTICS and analyzed in comparison with information stocked within the DATA BASE OF SENSOR'S FACTS. When performing a measurement there is the possibility to insert comments regarding events that may appear during the machining process (tool's wear, corrections etc). All this data are registered within the DATA BASE OF SENSOR'S FACTS (Fig. 2).

Data existing in the DATA BASE OF SENSOR'S FACTS are statistically interpreted and displayed as diagrams, emphasising the XR, XS and CP parameters, the control limit. With their help the process can be analyzed and kept under control in order to obtain a maximum stability.

The program runs under Windows operating system, and the data acquisition from instruments is being carried out by means of standard interfaces: serial RS232 or USB.

The role of Monitoring ES is that to process the information from all sensors translating information in the context of their interaction of all factors of the process from the viewpoint of the events stored within the database.

If the solutions are in a critical level, the system architecture allows direct passage in taking decisions, such as the immediate stop of the car in case that a threat against the operator is being pointed out.

2.2. SE- diagnosis

The diagnosis of Machine-Tools consists in detecting damages of the operation, locating and identifying the causes and forecasting the time-history of damage.

The database consists of events that took place with sensors before their mounting as well as after, causes that led to various interventions upon it, changes that have been made in the structure of the car and their history. The parameters given by this are the result of some actions upon the car, actions that require an interpretation that characterizes a car event (the engine temperature

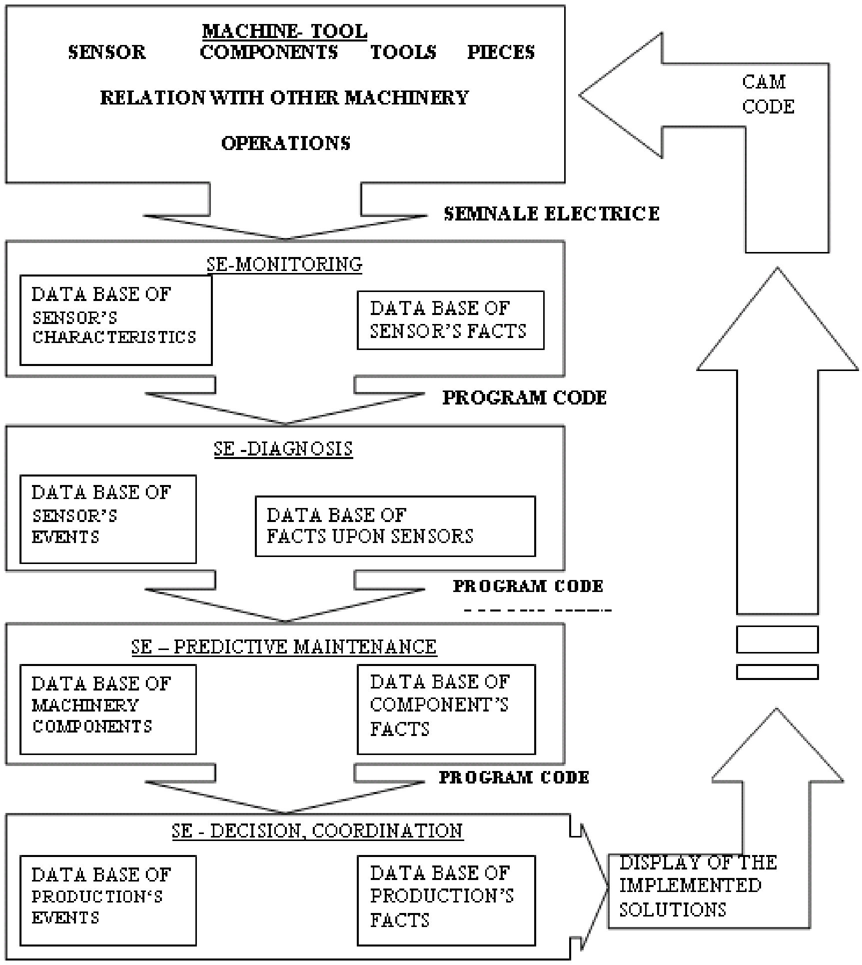

Fig. 2. The architectural system diagram.

rises when running load, but it is observed when it rises too much, so the cause of this effect should be sought or deducted from other information such as the possibility of tool wear). In here the ES can diagnoses the state of the various components of the car by offering a set of parameters for these components (the remaining life time for tool, engine, and oil of the hydraulic system).

The subsystem is able to provide a clear vision upon the state of machine-tool by analyzing the previous events stocked within the database of sensor's facts. The need for this subsystem SE- Diagnosis is the date following subsystem, with data solutions needed here.

2.3. SE- predictive maintenance

The predictive approach can be applied for any equipment problems, if one can measure various parameters such as vibrations, temperature, pressure, current or resistance. There has to be a limit from the technological point of view so that a problem can be detected during routine inspections. The limit should be low enough in order to detect the problem before equipment failing.

The database of car components provides all solutions offered by the ES-Diagnosis, confronting this information with the latest received solutions one can determine with accuracy where is better to intervene so that the car suffer no other damages (the strong vibrations due to wear bearings can damage other parts of the car and they need to be changed).

The database of events plays a very important role in reporting false defects (repeatedly damage of some parts can be due to other parts that although work in normal parameters can also damage).

2.4. SE – decision, coordination

The Last ES of the architectural tree has the most important role, taking into account the solutions offered by all the other three subsystems, analysis the database of production events and will comply with the beneficiary requirements.

The implementation of a Super control for the automatic production system is being adequate as long as it can control and maintain a machine-tool to beneficiary's requirements that may require a high production to car wear detriment if that means car costs coverage. Therefore, all the solutions offered so far by the other three subsystems must be interpreted as being applicable to this final subsystem.

The action of this subsystem can be applied directly on the car, the operator being informed only about the decisions that have been made.

Thus, the control of the car's production takes into account all operating criteria, the performance as well as the management of the production.

3. MRICC 8 × 1250 – 6U CNC

M - the machinery;
R - the rotating table;
I - annular;
C - the column;
C - central;
8 - eight indexes of the rotating table;
1250 - the diameter of rotating table;
6U - six working units (3 vertical + 3 horizontal).

The machine has three independently vertical units, situated in 1V1, 2V1, 3V1 stations that simultaneously machine the three holes used for mounting the thermal screen, by means of the leading slides, the force ends and the multi-broaches (multi-axis) ends. The machine also has three units inclined 5° with respect to horizontal plane, situated in 1H1, 2H1, 3H1 stations, with the same type of slides and force ends, but having the multi-broaches ends with two axes each, in order to simultaneously machine/dress/process the holes needed for mounting the exhaust flange.

The conveyance of the four devices used for mounting the “K” collectors is being carried out by an annular rotating table ϕ 1250, that is driven in the rotating movement by a motoreductor type PRC052-14.5 – 2.2 KW/1500 rpm which assures a 45° rotation in 2 seconds maximum. The six control devices (three in the vertical plane and three in the horizontal plane) that are situated in the vertical plane as well as in the horizontal plane, 45° with respect to working units, are used for checking the existence of holes performed at each working station, by means of some rods driven by pneumatic cylinders type SSD (flat). The working leads are carried out by slides having servo-engines SIEMENS type 1FT6064-1A71, those for vertical units having brake servo-engines. These servo-motors are actuated by frequency variators (digital) that allow a continuous variation of the speed/number of revolutions (Fig. 3).

The command and the control of the leads (motions-speeds) are realized by the CNC-SIEMENS 840D equipment. The displacement on the axes is being controlled by displacement transducers. The end motions and the “0” position are defined by means of the servo-engines transducers.The slide conveyors consist of two rails and landing skids having pre-tensioned balls. The lubrication of these conveyors and the ball screws is realized using oil.

The piece used for machining the “K” collector is made of cast iron GS53 according to N02.21.001. The base of “K” collector is being performed in a special mounting device, by its laying on the locating surface “A” and on a special auxiliary support (self moulding), with stabilization on rods having inclined planes at 3°.

The clamping of the working piece is being realized mechanical by means of three special single-actuating hydraulic cylinders. The clamping force in each of the three points is 120 daN and it is performed by means of special compression springs situated outside the hydraulic cylinders.

NOTE:

1. The frame;
2. The annular rotating table Ø 125 mm;
3. The central column;

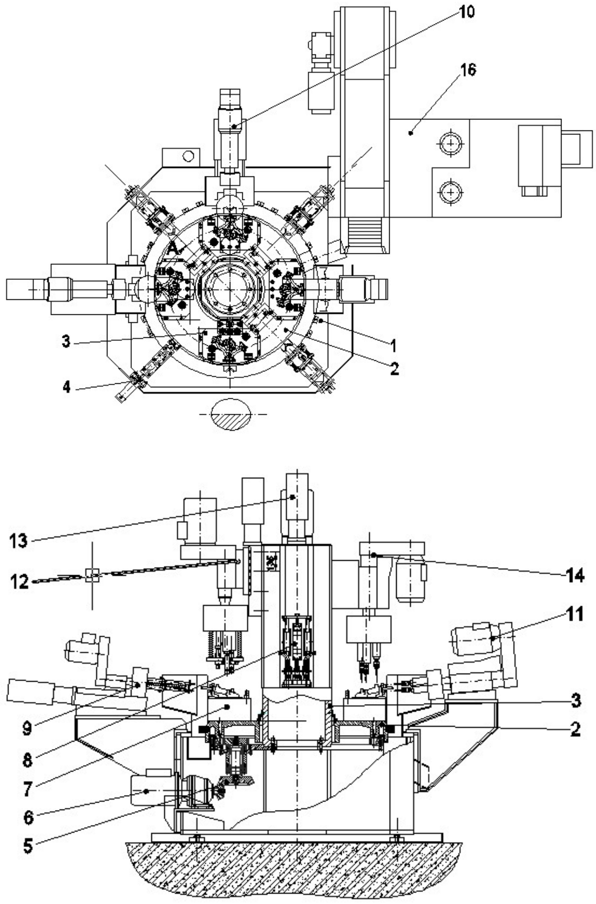

Fig. 3. Generally drawing MRICC 8 × 1250 – 6U CNC.

4. The indexing mechanism;
5. The drive mechanism of the annular rotating table;
6. The motoreductor 2,2 KW / 1500 rpm;
7. The mounting device;
8. The coupling-uncoupling mechanism;
9. The working station 1H1;
10. The working station 2H1;
11. The working station 3H1;
12. The working station 1V1;
13. The working station 2V1;
14. The working station 3V1;
16. Device for tool control;

The release of the piece is being carried out by lifting and rotating at 90° the fixing straps, using the hydro drive at p = 100 bar. The hydraulic pressure within the three special single-actuating hydraulic cylinders and the hydraulic cylinder for releasing the auxiliary support (p = 30 bar) is being assured by means of a coupling-uncoupling mechanism situated in The Loading-Unloading Station. This mechanism has the role of bringing the hydraulic pressure from the tank of the HYDRAULIC PANNEL to the hydraulic cylinders of the clamping devices (successive) by means of automatic quick couplings G ½.

4. THE MAIN TECHNICAL CHARACTERISTICS

In order to clear define the context within the machinery performs, the characteristics, parameters and operations of the working pieces as well as the relation of machinery with the other machinery in the production line must be known. The special unit machinery MRICC 8 × 1250 - 6U CNC consists of:

- vertical leading slides type UA35-CNC-Am (working stations 1V1+2V1): stroke = 150 mm;
- servo-engine type 1FT6064-1A71-4EH1, with brake (for vertical leading slides): 2.2 Kw/3000 rpm, M0 = 9.5 Nm;
- horizontal leading slides type UA35-CNC-AM (working stations 1H1+2H1): stroke = 150 mm;
- servo-engine type 1FT6064-1A71-4EG1, no brake (for horizontal leading slides): 2.2 Kw/3000 rpm, M0 = 9.5 Nm;
- force head for drilling/lamer, type BEX 35-K (for the vertical working stations 1V1+2V1): bore cone, ISO 40;
- force head for drilling/lamer, type BEX 15-K (for the horizontal working stations 1H1+2H1): bore cone, ISO 30;
- multi-broaches head for drilling/lamer, type MHFS 8-200-3 (for the vertical working stations 1V1+2V1): ϕ 200 mm/3 axes;
- multi-broaches head for drilling/lamer, type MHFS6-200-2 (for the horizontal working stations 1H1+2H1): ϕ 200 mm/2 axes;
- multi-broaches head for cutting, type MHFS 8-200-LAS (for the vertical working station 3V1): ϕ 200 mm/3 axes;
- multi-broaches head for cutting, type MHFS6-200-LAS (for the horizontal working station 3H1): ϕ 200 mm / 2 axes;
- cutting unit type GEM 20C (for the vertical working station 3V1 and the horizontal station 3H1): Power/electric motor rotative speed: 1.5 Kw/1435 rpm;
- feed screw type LP 20C for the cutting units type GEM 20C: pitch = 1.25 mm;
- pneumatic cylinders for the control stations, Diameter/stroke: ϕ 50/100 mm;
- hydraulic cylinder for the indexing mechanism, Diameter/stroke: ϕ 50/100 mm;
- motoreductor for the drive mechanism of the annular rotating table, Power/Rotative speed 2.2 Kw/1500 rpm;
- Device for tool control (Fig. 4), Adjustment capacity: 8 drilling, lamer and cutting tool-holders.

Table 1

Operating speeds

Working station	**Rate of cutting m/min**
Station 1V1 – lamer ϕ 23	43.30
Station 2V1 – Drilling ϕ 6.75/ϕ 10	31.80 / 47.10
Station 3V1 – Cutting M7.96 x 1.25	15.00
Station 1H1 – Drilling ϕ 6.75 / ϕ 10	31.80 / 47.10
Station 2H1 - lamer ϕ 12	33.90
Station 3H1 – Cutting M7.96 × 1.25	15.00

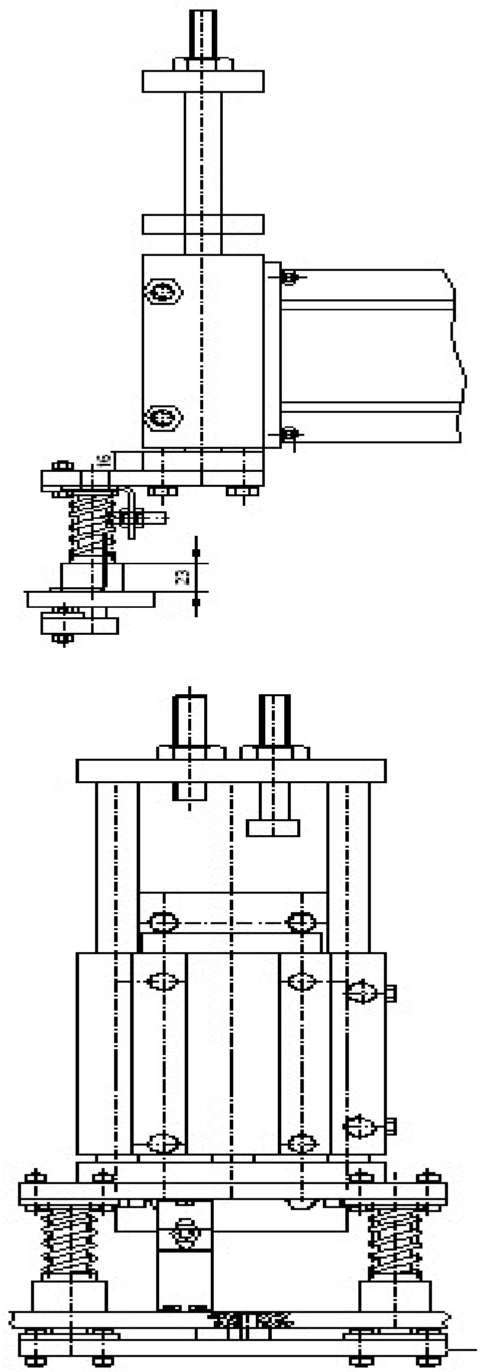

Fig. 4. Control devices.

Technological operations for working the “K” collector (table 1):

- working station 1V1 – lamare (3 lug boss): ϕ 23 mm;
- working station 2V1 – Drilling (3 holes): ϕ 6.75/ϕ 10 mm;
- working station 3V1 – Cutting (3 holes): M7.96 x 1.25 mm;
- working station 1H1 - Drilling (2 holes): ϕ 6.75 / ϕ 10 mm;
- working station 2H1 – lamer (2 holes): ϕ 12 mm;
- working station 3H1 - Cutting (2 holes): M7.96 x 1.25 mm.

All 6 working units are part of the following WORKING STATIONS (Table 1):

- Station 1V1 – for the vertical lamer unit 1, 3 × ϕ 23 mm
- Station 2V1 – for the vertical drilling unit 2, 3 × ϕ 6.75/ϕ 10 mm;
- Station 3V1 - for the vertical cutting unit 3, 3 × M7.96 × 1,25 mm;
- Station 1H1 – for the horizontal drilling unit 1, 2 × ϕ 6.75 / ϕ 10 mm;
- Station 2H1 - for the vertical lamer unit.2, 2 × ϕ 12 mm;
- Station 3H1 - for the vertical cutting unit 3, 2 × M7.96 × 1.25 mm.

Additional to THE WORKINK STATIONS, the MRICC 8 × 1250-6U machinery has 6 control stations, 3 stations in the vertical plane and 3 in the horizontal plane.

The working stations 1V1, 2V1, 3V1 and the vertical control stations 1V1', 2V1', 3V1' are based and clamped on a central octagonal column set on the machinery frame.

The working stations 1H1, 2H1, 3H1 and the horizontal control stations 1H1', 2H1', 3H1' are mounted on special supports – welded construction, that are set on the machinery frame.

6. CONCLUSIONS

The architectural pattern is composed looking for the maximum high degree of functional independence between the parts (ex: expert systems).

Each one of these realises macro-functions in the subject system and works interactive with each one, creating the entire Supercontrol.

A political strategy was adopted for each subsystem: "divide for performance", meaning that the whole functions must be distributed in spare parts with simple actions but still having the complex relation between them.

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